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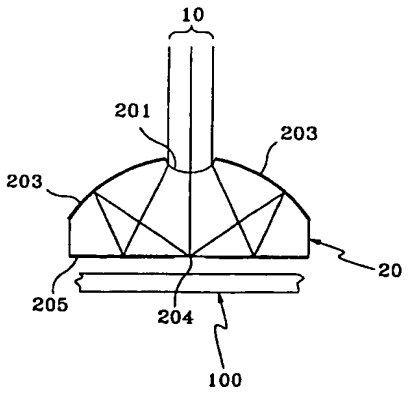
(54) Title: CATADIOPTRIC OPTICAL SYSTEM, OPTICAL PICKUP AND OPTICAL DISK DRIVE EMPLOYING THE SAME, AND OPTICAL DISK

(57) Abstract

An optical focusing system which uses a light beam emitted from a light source, includes a refractive surface on one side of the optical focusing system and having a first radius of curvature, a first reflection surface on the above one side, surrounding the refractive surface and having a second radius of curvature being different from the first radius of curvature, a transparent beam focusing surface on the other side of the optical focusing system, and a second reflection surface on the above other side and surrounding the beam focusing surface. The refractive surface refracts an incident light beam, the second reflection surface reflects a light beam refracted by the refractive surface toward the first reflection surface, and the first reflection surface focuses a laser light beam reflected from the second reflection surface on the beam focusing surface as a focused beam spot. The optical focusing system can be used in an optical pickup. The optical pickup uses the optical focusing system to generate, from a light beam e.g. laser light emitted from a light source, a beam spot used for recording or readinginformation to a recording medium. The optical pickup uses a near field effect provided by an optical focusing system according to the present invention, to allow a superior density of recording or reading. Further, the optical focusing system according to the invention can use a light beam having a beam diameter smaller than that of the laser beam used for an existing optical focusing system for forming a near field. Thus, the optical pickup according to the invention can record or read information on an optical disk having a surface recording density of 10Gbit/inch^2 or more. Even if an incident light beam inclination occurs due to movement of the disk or the optical pickup, information can be recorded on or read from a disk accurately. Also, the assembly of the optical focusing system and the adjustment of the assembled optical focusing system are easily performed.



(NA) is also increased to NA/λ. Thus, a size of the light spot which is finally formed in the inside of the surface of the spherical lens 2 is proportional to NA/λ. As a result, the size of the spot can be reduced using the refractive index "n" of the medium of the spherical lens 2.

However, the optical focusing system of Fig. 1 includes the aspherical lens 1 and the spherical lens 2 which are separately manufactured. Accordingly, it is hard to assemble or adjust the optical focusing system so that a desired optical characteristic is obtained. Since the optical focusing system requires incident laser light having a beam diameter more than or equal to 3mm, the size of all optical components including a light reception unit are enlarged. As well, in the case where the inclination of incident beam that a laser beam deviates from a normally used angle with respect to an optical disk occurs due to sway of a moving optical pickup or a rotating optical disk, it is difficult to record or reproduce a signal normally.

Further, the shortest wavelength of light of a currently available laser diode light source is about 600nm.

Also, the numerical aperture of the objective lens is approximately 0.6 at present. Thus, in the case where a numerical aperture of 0.6 or more is required, performance of an optical pickup is much sensitive to inclination of an incident beam. Accordingly, it is difficult to use the existing optical focusing system in order to commercialize an optical recording and/or reproducing apparatus.

Disclosure of Invention

Thus, it is a first object of the present invention to provide an optical focusing system for focusing a light beam using a novel optical system, to thereby have an excellent performance with respect to an incident beam inclination, make optical components compact and reduce the size of a focused light spot.

A second object of the present invention is to provide an optical pickup employing the above optical focusing system.

A third object of the present invention is to provide a method for fabricating the above optical focusing system.

A fourth object of the present invention is to provide an optical disk driver employing the above optical focusing system.

A fifth object of the present invention is to provide an optical pickup including a readout layer for amplifying a light beam containing information recorded on an optical disk.

A sixth object of the present invention is to provide an optical disk to allow more precise read of recorded information.

To accomplish the first object of the present invention, there is provided an optical focusing system for use with a light beam for forming a focused beam spot. The optical focusing system comprises, a refractive surface on one side of the optical focusing system and having a first radius of curvature; a first reflection surface on said one side, surrounding the refractive surface and having a second radius of curvature being different from the first radius of curvature; a transparent beam focusing surface on the other side of the optical focusing system; and a second reflection surface on said other side and surrounding the beam focusing surface,

wherein the refractive surface refracts an incident light beam, the second reflection surface reflects a light beam refracted by the refractive surface toward the first reflection surface, and the first reflection surface focuses a laser light beam reflected from the second reflection surface on the beam focusing surface, as a focused beam spot.

The second object of the present invention is accomplished by an optical pickup for an optical disk. The optical pickup which records and/or reads information to an optical disk using a focused beam spot, comprises,

a light source;

optical detection means;

an optical head comprising,

a refractive surface on one side of the optical head and having a first radius of curvature;

a first reflection surface on said one side, surrounding the refractive surface and having a second radius of curvature being different from the first radius of curvature;

a transparent beam focusing surface on the other side of the optical head: and

a second reflection surface on said other side and surrounding the beam focusing surface,

wherein the refractive surface refracts an incident light beam, the second reflection surface reflects a light beam refracted by the refractive surface toward the first reflection surface, and the first reflection surface focuses a laser light beam reflected from the second reflection surface on the beam focusing surface as a focused beam spot,

optical path altering means for transferring a light beam emitted from the light source to the refractive surface of the optical head and transferring a light beam outgoing from the refractive surface to said optical detection means; and

a supporting means to which the optical head is attached, elastically supporting the optical head so that the optical head moves in the direction perpendicular to said loaded optical disk, within a predetermined distance from said loaded optical disk.

The third object of the present invention is accomplished by a method for manufacturing an optical focusing system which use with a light beam for forming a focused beam spot and comprises, a concave refractive surface on one side of the optical focusing system and having a first radius of curvature, a convex first reflection surface on said one side, surrounding the refractive surface and having a second radius of curvature being different from the first radius of curvature, a transparent beam focusing surface on the other side of the optical focusing system, and a second reflection surface on said other side and surrounding the beam focusing surface, wherein the refractive surface refracts an incident light beam, the second reflection surface reflects a light beam refracted by the refractive surface toward the first reflection surface, and the first reflection surface focuses a laser light beam reflected from the second reflection surface on the beam focusing surface, the manufacturing method comprising a step of:

fabricating a mold for the refractive surface and the first reflection surface from a primary mold plate.

A diamond cutting method is used in the step of fabricating, and the step of

fabricating comprises sub-steps of:

cutting the primary mold plate, to create a first mold for a shape of the first reflection surface;

forming, in the first mold, a through hole in which a second mold for a shape of the refractive surface is inserted; and

inserting the second mold into the through hole formed in the first mold.

Also, the present invention provides an optical disk drive for recording and/or reading information to an optical disk using a focused beam spot, the optical disk drive comprising:

a base;

a light source;

a reflector;

optical detection means;

an optical head comprising,

a refractive surface on one side of the optical head and having a first radius of curvature;

a first reflection surface on said one side, surrounding the refractive surface and having a second radius of curvature being different from the first radius of curvature;

a transparent beam focusing surface on the other side of the optical head; and

a second reflection surface on said other side and surrounding the beam focusing surface,

wherein the refractive surface refracts a light beam incident from the reflector, the second reflection surface reflects a light beam refracted by the refractive surface toward the first reflection surface, and the first reflection surface focuses a laser light beam reflected from the second reflection surface on the beam focusing surface as a focused beam spot,

optical path altering means for transferring a light beam emitted from the light source to the reflector and transferring a light beam reflected from the refractive surface to said optical detection means; and

a supporting means to which the optical head is attached, elastically supporting the optical head so that the optical head moves in the direction perpendicular to said loaded optical disk, within a predetermined distance from said loaded optical disk.

There is also provided an optical pickup for reading information from an optical disk using a near field, the optical pickup comprising:

an optical focusing system for generating a near field for reading information from a loaded optical disk; and

a readout layer attached on a optical surface of the optical focusing system facing toward said loaded optical disk, for amplifying a reflected light beam containing information recorded on a recording layer of said loaded optical disk.

It is also provided an optical disk for use with an optical pickup for using a near field for reading information, the optical disk comprising:

a substrate;

a recording layer applied over the substrate and on which information is recorded;

a readout layer applied on the recording layer, for amplifying a light beam containing information recorded on the recording layer;

a dielectric layer applied on the readout layer; and

an overcoat layer applied on the dielectric layer.

Brief Description of Drawings

The preferred embodiments are described with reference to the drawings, wherein:

Fig. 1 is a view for explaining a conventional optical focusing system for generating a near field;

Fig. 2 is a view for explaining an optical focusing system according to a preferred embodiment of the present invention;

Figs. 3A through 3C are views for explaining optical focusing systems for a magneto-optical disk which are modified from the optical focusing system shown in Fig. 2;

Figs. 4A through 4C are views for explaining modifications of the optical

and so on. However, the refractive surface 201 and the beam focusing surface 204 are not processed by a reflection coating, and have a light transmission characteristic. The refractive surface 201 and the beam focusing surface 204 include the optical axis of the optical focusing system 20. The first reflection surface 203 is disposed at the outer area of the refractive surface 201, and the second reflection surface 205 is disposed at the outer area of the beam focusing surface 204. An optical surface which is composed of the beam focusing surface 204 and the second reflection surface 205 has a shape of a plane surface or a curved shape close to the plane surface.

The refractive surface 201 which has a shape of a spherical surface being concave or recessed toward the beam focusing surface 204. the first reflection surface 203 has an aspherical shape. The refractive surface has a first radius of curvature and the first reflection surface has a second radius of curvature having an absolute value larger than that of the first radius of curvature. According to convention of signs, all convex surfaces have a positive radius of curvature and all concave surfaces have a negative radius of curvature. Therefore, the refractive surface 201 has the first radius of curvature of the negative sign and the first reflection surface 203 has the second radius of curvature of the negative sign. The optical focusing system 20 is designed so that the aperture of the refractive surface 201 is sufficiently smaller than that of the optical focusing system 20. That is, the optical focusing system is designed so that on the optical surface of the optical focusing system 20 located on the light source side, the refractive surface 201 has much smaller occupancy than the first reflection surface 203. Also, the optical focusing system is designed so that most of the laser light beam having been reflected from the first reflection surface 203 is focused on the beam focusing surface 204.

The refractive surface 201 refracts a light beam incident from a light source in a divergent form. The first reflection surface 203 reflects the light beam reflected from the second reflection portion 205 after being refracted by the refractive portion 201, toward the beam focusing surface 204 positioned on the center of the optical surface which is located toward the optical disk 100. Thus, the optical focusing

FIG. 1 (PRIOR ART)

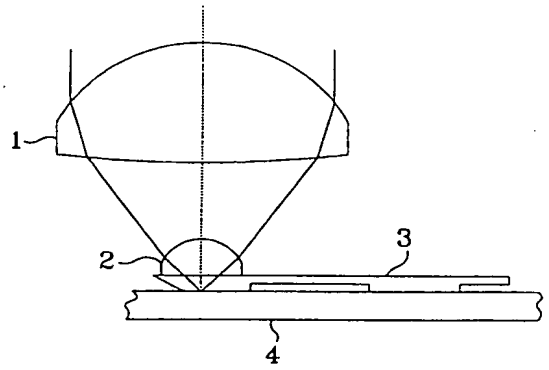


FIG. 2

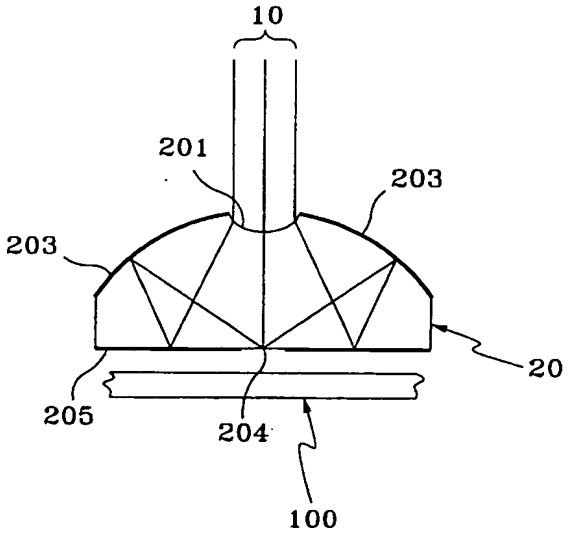


FIG. 6

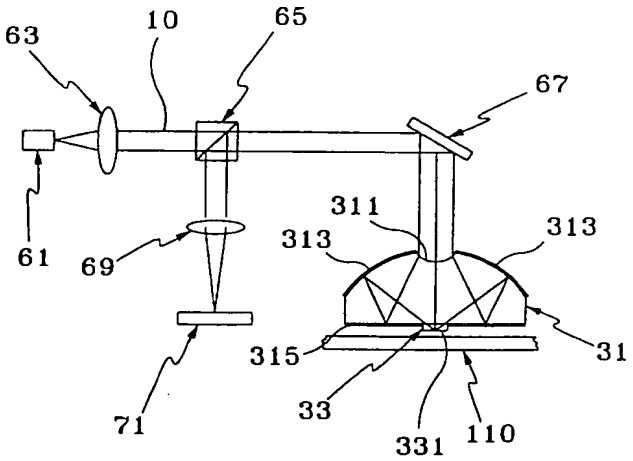


FIG. 7A